UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 31, 2022

MEMORANDUM TO: Raj Iyengar, Chief
Reactor Engineering Branch
Division of Engineering
Office of Nuclear Regulatory Research

FROM: Doug Eskins, Reactor Engineer ***/RA/***
Reactor Engineering Branch
Division of Engineering
Office of Nuclear Regulatory Research

SUBJECT: SUMMARY OF THE OBSERVATION PUBLIC MEETING ON REGULATORY CONSIDERATIONS AND OPPORTUNITIES FOR DIGITAL TWINS IN NUCLEAR REACTOR APPLICATIONS

On March 1, 2022, the U.S. Nuclear Regulatory Commission (NRC) held an observation public meeting with representatives from the Electric Power Research Institute (EPRI), the Department of Energy (DOE) Advanced Research Projects Agency - Energy (ARPA–E), and the Nuclear Energy Institute (NEI) to provide updates on NRC's future focused research project on the regulatory viability of digital twins and to discuss regulatory considerations and opportunities for digital twins in nuclear reactor applications. The research efforts of each organization relevant to digital twin technologies were discussed. The meeting was held via Teams due to the Coronavirus Disease 2019 (COVID-19) pandemic.

The meeting was opened by Stephanie Coffin, Deputy Director, Office of Nuclear Regulatory Research. Ms. Coffin provided background on the NRC's future focused research (FFR) program and an introduction to the NRC digital twin FFR project.

Dr. Doug Eskins, Reactor Engineer, Office of Nuclear Regulatory Research, provided an overview of the NRC digital twin project including a description of a digital twin system and its associated problem space, as well as project accomplishments, collaborations, future activities, and takeaways.

Dr. Jennifer Shafer, Program Director, ARPA–E, provided an overview of ARPA–E, their advanced nuclear energy portfolio, and their efforts to develop innovative digital technologies. Dr. Shafer focused on the Modeling-Enhanced Innovations Trailblazing Nuclear Energy Reinvigoration (MEITNER) and Generating Electricity Managed by Intelligent Nuclear Assets (GEMINA) programs and talked explicitly about the GEMINA program, including GEMINA digital twin development efforts.

Dr. Hasan Charkas, Principal Technical Leader, EPRI, provided updates on EPRI's work to develop digital twin guidance for advanced reactors, use cases, and definitions, as well as creation of a digital twin for construction, their plans to start small and scale up, and the need for common frameworks and collaboration.

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Mr. Richard McGrath, Principal Technical Leader in Radiation Safety Group, EPRI, continued the EPRI presentation by discussing a specific digital twin use case for supporting radiation protection at nuclear powerplants by enabling a centralized 3D radiation monitoring and control center.

Mr. Ben Holtzman, Program Advisor, New Reactors & Advanced Technologies, NEI, provided an industry perspective on the applications of digital twin within the nuclear industry. His discussion distinguished among applications that would or would not require NRC engagement, the use of digital twin to reduce uncertainties, and the need to make a business case prior to digital twin adoption by industry.

At the end of the NEI presentation, Dr. Raj Iyengar, Branch Chief, Office of Nuclear Regulatory Research, moderated a discussion among the meeting participants. Many topics were discussed including approaches to implementing digital twins and the need for digital twin business cases, lessons learned, reductions in regulatory uncertainty, and the development of common frameworks, standards, and guidance. Some specific discussions are summarized below.

Jim Slider of NEI mentioned the need for collaborative efforts to develop key concepts and a common language and framework for digital twin as well as a plan for and future conversations about developing regulatory guidance. Dr. Iyengar and Dr. Eskins responded that the current future focused research phase of NRC research is limited to describing the nuclear digital twin problem space and identifying regulatory considerations. The next phase of digital twin research will involve interactions with NRC regulatory staff to discuss a strategy for regulatory readiness for applications of digital twins technologies.

Mr. Holtzman of NEI remarked that digital twins need to first be implemented on a small scale, especially within the existing fleet, to gain understanding of how digital twins can be used to make plants more efficient, more productive, and more economical. NEI and EPRI both pointed to the fact that a digital twin can be used within current regulations as a tool to gain insights and inform certain plant decisions in areas such as operations and maintenance.

Dr. Hasan of EPRI remarked that the end user, utilities, may find a digital twin useful in construction to provide oversight and coordination between end users and technology providers. He also remarked that a centralized framework or guidance on a framework would be helpful for coordinating all parties involved in construction, and both NEI and the NRC need to work toward such a framework.

After discussion between the NRC staff and the meeting participants, the NRC staff provided the public an opportunity to provide comments or ask questions.

Dr. Iyengar thanked the participants and closed the meeting.

The list of attendees is provided in the Appendix. All presentations and other information related to this public meeting (e.g., meeting notice and agenda) are available on the NRC's Agencywide Documents Access and Management System (ADAMS), Accessions ML22060A001 and ML22054A288, respectively.

APPENDIX

Attendees at March 1, 2022 Observation Public Meeting on Regulatory Considerations and Opportunities for Digital Twins in Nuclear Reactor Applications

Name	**Affiliation**
Aamir	
Alex Brazalovich	X-energy
Alexander Pingel	Westinghouse
Harry Andreades	Advanced Research Projects Agency–Energy (ARPA–E)
Gregory Banyay	Westinghouse
Jana Bergman	
Ram Bhuma	GE Digital
Brad Crotts	Orano
Edward Bradley	International Atomic Energy Agency (IAEA)
Rob Burg	Engineering Planning and Management, Inc.
Jesse Carlson	U.S. Nuclear Regulatory Commission (NRC)
Gene Carpenter	U.S. Department of Energy (DOE)
Chad	
Nachiketh Chandran	NRC
Hasan Charkas	Electric Power Research Institute (EPRI)
Clevin Canales	X-energy
Stephanie Coffin	NRC
Edward Coulter	
Eric Mollen	Neal R. Gross & Co
Christopher Courtenay	Duke Energy
Curtis Smith	Idaho National Laboratory (INL)
Dan Beattie	Dassault Systems
Mishca de Costa	Ontario Power Generation (OPG)
Edwin Lyman	Union of Concerned Scientists
Doug Eskins	NRC
Nathan Faith	Constellation Nuclear
Leo Fifield	Pacific Northwest National Laboratory (PNNL)
Eric Focht	NRC
Daniel Foster-Roman	OPG
Frederic Grant	Simpson Gumpertz & Heger Inc. (SGH)
Raymond Furstenau	NRC
Ramon Gascot Lozada	NRC
Han Bao	INL
Roy Hardin	NRC
Michelle Hayes	NRC
Matthew Hiser	NRC
Benjamin Holtzman	Nuclear Energy Institute (NEI)
Alex Huning	Oak Ridge National Laboratory (ORNL)
Ian Davis	X-energy
Ian McGaw	Gafcon, Inc.
Ian Stevenson	Dassault Systems

Ingrid Nordby	X-energy
Raj Iyengar	NRC
Prashant Jain	ORNL
Jean LeClair	Laurentis Energy Partners
John Merickel	INL
Jonathan Kyle	Ansys
Robert Krsek	NRC
Kurt Harris	Flibe Energy
Lance Larsen	Information Systems Laboratories (ISL)
Daniel Lau	
Ming Li	NRC
Linyu Lin	INL
Yong Chang Liu	Canadian Nuclear Safety Commission
Louise Lund	NRC
Matthew Mann	GE Power Portfolio
Mariana	
Tim Marshall	NRC
Matt Hertel	X-energy
John McKirgan	NRC
Michelle Quirk	Los Alamos National Laboratory (LANL)
Miguel Sanchez Perea	Spanish Consejo de Seguridad Nuclear
Frank Mischler	Hitachi America, Ltd.
Misra Parames	OPG
James Moon, Jr	
Brian Mori	OPG
Michael Muhlheim	ORNL
Daniel Mussatti	NRC
Curt Nehrkorn	DOE ARPA–E
Daniel Nichols	DOE
Pat Everett	Oklo
Stephen Philpott	NRC
Mihaela Quirk	DOE
David Rahn	NRC
Pradeep Ramuhalli	ORNL
Riccardo Cappa	SGH
Richard McGrath	EPRI
Serita Sanders	NRC
Satyan Bhongale	X-energy
Whitney Schiefner	OPG
Jenifer Shafer	DOE
Neil Sheehan	NRC
James Slider	NEI
Sofia Guerra	Adelard
Stephen Wood	
Stephen Vaughn	X-energy
Steven Pope	ISL
Todd Anselmi	INL

Robert Tregoning	NRC
Ian Tseng	NRC
Christopher Ulmer	NRC
Vaibhav Yadav	INL
Isabella Van Rooyen	INL
Tristan Villareal	NRC
Shakur Walker	NRC
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Public Meeting Memoranda DATE April 1, 2022

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